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DEPARTMENT OF THE ARMY  
Fort Detrick  
Frederick, Maryland

## PULMONARY TUBERCULOSIS AS AN OCCUPATIONAL DISEASE

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### *Laboratory Infection*

Jentgens has ably discussed the difficulties involved in appraisal of tuberculosis as an occupational disease and pointed out that because of these very difficulties the appraiser must strive for the highest degree of disinterestedness and objectivity. His interpretation of my article on "The Danger of Infection in the Tuberculosis Laboratory" [2], however, may lead to misunderstandings. In fact Jentgens makes statements in that connection which in my opinion require further explanation. With the kind permission of the editors I am therefore taking the opportunity of calling attention here to the possibilities of transmission of germs in the tuberculosis laboratory and to the consequences arising therefrom with regard to appraisal of a case of tuberculosis among the laboratory personnel.

### *Aerosol*

The most important ways of infection with tuberculosis in natural infection and in laboratory infection are compared in Table 1. In the present connection we shall deal chiefly with infection of the respiratory tract by mycobacteria.

By "aerosol" is meant a suspension of solid or liquid particles in a gas. As Jentgens quite correctly states, only particles in the range of size below  $5\mu$  ( $= 5 \times 10^{-4}$  cm) can reach the parts of the respiratory passages which are not protected by ciliated epithelium. Larger particles are caught and held in the upper parts of the respiratory tract, conveyed by the ciliary current to the oral cavity, and expectorated or swallowed.

Particles of a diameter of  $5\mu$  have a sedimentation rate of about 0.2 cm/sec [9]. By reason of continuous air currents in a space, an aerosol made up of particles of this order of magnitude is capable of remaining suspended for a long time. Tuberculosis bacteria are bacilli of 0.3-0.4 $\mu$  in width and 1-7 $\mu$  in length [7]. They occur singly or in small groups in the form of an aerosol capable of penetrating the lungs,

often surrounded by a protective layer of mucin, or in other words in the form of a droplet nucleus [17]. Detection of tuberculosis bacteria in aerosol form can only be accomplished by means of special apparatus [1], and not indirectly by trying to find the germs in room dust or bed dust. There the bacteria cling to dust particles whose size is considerably above  $5\mu$ , so that they usually do not come under consideration as far as the pulmonary channel of infection is concerned.

The question arises how an aerosol originates which contains tuberculosis bacteria and which is capable of floating and so can get into the lungs. In the course of the natural spread of tuberculosis it is produced by persons or animals in whose respiratory passages there are tuberculous foci. For reasons which are still largely unknown, some patients are capable, when coughing, sneezing, and speaking, of expelling tuberculosis bacteria especially frequently and abundantly in the form of particles which can enter the lungs. In the English and American literature such patients are called "spreaders" or "disseminators" [4,6,11,13]. On the other hand there are patent tuberculars who instead of these small droplets containing tuberculosis bacteria produce large ones and so are less dangerous to their associates. Finding and isolating the "dangerous spreaders," therefore, should be an objective of the first importance in prophylaxis of tuberculosis infection. [6].

As is well known from ordinary atomizers, it is not difficult to generate an aerosol mechanically. Many mechanical processes in the laboratory lead, surely better than patients are able to do it in coughing, to the formation of floating aerosols which contain or consist of microorganisms, depending on the nature of the material atomized. The mode of generation and particle-size spectrum of such aerosols have been investigated experimentally with the aid of various test germs [3; see additional literature there]. As Jentgens correctly states, tuberculosis bacteria have never been detected in the air of laboratories in the same way as for example in that of tuberculosis clinics [7,10]. But there is no reason why the results obtained in the experiment should not apply to tuberculosis bacteria [14]. Thus if material containing tuberculosis bacteria (e.g. sputum) or tuberculosis cultures are centrifuged, homogenized, or otherwise violently and abruptly agitated in the laboratory, the possibility exists that tuberculosis bacteria are liberated in the form of particles which can enter the lungs and that they remain suspended for a long time in the air of the room. The process takes place unremarked, just as does the generation of a germ-laden aerosol by a patient. It should be mentioned for the sake of completeness that besides the constant exposure in the laboratory there can be short-term massive exposures in consequence of occurrences which usually go unnoticed.

#### *Appraisal*

Both in the laboratory and at tuberculosis clinics tuberculin-positive persons are commonly employed. More than an occasional contact with tuberculosis bacteria is necessary, as Jentgens writes, for the occurrence of a superinfection. We must further agree with Jentgens when he observes that living in association with patent tuberculars is to be regarded as dangerous. But I regard being constantly in a tuberculosis laboratory as equally dangerous. Just as there are

Table 1. Mode of Infection in Tuberculosis

Mode of Transmission	Organ Principally Affected	Natural Infection	Infection in the Lab
Contact	Skin, mucous membrane	Contact with TB material (e.g. milkers, butchers) Artif.: BCG inoculation	Wounds with TB material, injections (usually accidental occurrences)
Vehicle, dust	Gastro-intestinal tract	TB-contaminated food, swallowing TB bacteria	Swallowing infectious material, e.g. in pipetting
By air (aerosol)	Lungs	TB aerosol produced by "dangerous spreaders"	1. Aerosol-generating work procedures a) unrecognized, considered harmless b) accidental occurrences 2. Patients or lab animals as spreaders

germ spreaders at the tuberculosis clinic, here there are aerosol-generating work procedures, which are often considered harmless and for that reason are all the more fraught with consequences. Tuberculosis bacteria get into the air that we breathe in the form of particles which can reach the lungs, and because of continuous or ever-recurring exposure lead to superinfections. For this reason Jentgens does agree that in the preparation of cultures, in resistance determinations, and in animal experiments a danger to the personnel is certainly to be assumed. But this is also true for the study of sputa containing tuberculosis bacteria, which for purposes of concentration and other purposes depending on the study must be agitated, centrifuged, and smeared on slides.

The circumstance that a laboratory employee has to deal constantly with infectious material should, like the fact of contact with patent tubercular patients, be grounds for the appraiser's assuming a tubercular infection as probably occupationally conditioned. We must always reckon with the presence of germ-laden aerosols in the laboratory, since it is hardly possible to carry out all work with material containing germs under a hood. Protective measures of this kind are urgently necessary [2,3,16], even though carrying them out in practice encounters not inconsiderable difficulties.

In a refutation of my contribution to the discussion [4] Wundt [18] does not deny the exposure of laboratory personnel to microbic aerosols. Whether nurses at tuberculosis clinics or medical technical assistants in tuberculosis laboratories are relatively more exposed need not be decided. Pike et al. [9] call attention to the fact that many tuberculous infections in the laboratory are not even reported as occupational diseases because of lack of knowledge of the circumstances. My plea to appraisers is not to fail in their highly responsible work to

take account of the fact that

- a) Laboratory personnel are also extremely endangered by tuberculosis [2,4,5,16],
- b) a high percentage of all diseases in the laboratory are transmitted by way of the air [15], and
- c) tuberculosis is a true airborne infection [6,11,12].

The notion that occupationally conditioned illnesses in the laboratory come about only after accidents and as a result of unworkmanlike procedures has been refuted experimentally and empirically and should therefore be given up as incorrect.

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